

# Color Transparency at ELFE<sup>1</sup>

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## Abstract

We review the presentations given in the Color Transparency parallel session held during the second ELFE workshop.

## 1 Introduction

Color Transparency experiments are one of the major goals of the ELFE project, as already emphasized[1]. The concepts behind Color Transparency are now well known: a hard exclusive scattering (with a typical large  $Q^2$  scale) selects a very special quark configuration in a hadron: the minimal valence state where all quarks are close together, a small size color neutral configuration sometimes referred to as a *mini hadron*. Such a color singlet system cannot emit or absorb soft gluons which carry energy or momentum smaller than  $Q$ . This is because gluon radiation — like photon radiation in QED — is a coherent process and there is thus destructive interference between gluon emission amplitudes by quarks with “opposite” color. Then, the recoiling small components have much reduced strong interactions with other nucleons due to this shielding of color.

The first letter of intent[2] emphasized the measurement of the  $(e, e'p)$  cross section on several nuclei and if possible the normal component of the recoil polarization. Much work has been done since this time, both theoretically and experimentally[3]. Experimental results have been obtained at SLAC and FNAL, proposals are approved at CEBAF and HERMES, and new theoretical ideas have been pursued in many directions. This parallel session which we briefly review has given the opportunity to discuss some of these new ideas.

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<sup>1</sup> Report on the Color Transparency parallel session held during the second ELFE workshop, Saint Malo, France, September 1996.

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## 2 Theoretical background

Strong interaction physics is a fascinating problem and one expects color transparency experiments to shed light on some of its aspects. Whether lattice computations will solve and explain confinement is still an open question and many theorists[4] pursue an effort to extract from continuum studies some information on basic quantities such as the gluon propagator in a Schwinger-Dyson approach.

How to set the scale of final state interactions in  $(e, e'p)$  reactions needs a careful examination of the eikonal approximation in a completely non-relativistic regime. The Glauber method involves the linearization of the wave equation for the ejected proton travelling through the residual nucleus. The consequences of such an assumption at high proton momenta has been studied[5] by comparing the results with the predictions obtained when the second-order differential equation for the proton wave is solved exactly for each partial wave.

## 3 Electroproduction of vector mesons from nuclei

Diffractional electroproduction at large  $Q^2$  involves the pointlike production of a  $q\bar{q}$  pair, its propagation through the medium. Whether the formation of a genuine vector meson occurs after or during the travel through the nucleus is of course a matter of Lorentz boost. The physical picture of this process has now been developed in many details and the presentations of G. Piller[6] and B. Kopeliovich[7] pointed out several new aspects.

The multichannel evolution equation approach developed by B. Kopeliovich[7] for the density matrix describing a hadronic wave packet produced by a virtual photon and propagating through nuclear matter or the vacuum is dual to the quark-gluon representation. A new procedure of data analysis has been proposed to provide an unambiguous way of detection of a color transparency signal even at medium energies.

Using a polarized deuteron offers many advantages: this simplest bound state of nucleons has been much studied previously and one may say that its wave function is well-known up to  $350\text{MeV}$ , a limit which may be extended by on-going experiments at NIKHEF, MAMI and CEBAF. Moreover, only single and double scattering should be included, the latter ones probing smaller  $pn$  configurations. Kinematic regions are determined[6] where the final state interaction of the initially produced quark-antiquark pair contributes dominantly to the coherent leptonproduction cross section.

## 4 Towards a new experimental proposal

Much of the literature on colour transparency in the past has concentrated on the aspect of "transparency", i.e. the reduction of absorption when a nucleon in the 'small' Fock state traverses a nucleus. One of the main difficulties of this idea relates to the short lifetime of the Fock state selected in a high-momentum transfer process. The lifetime of this state is typically of the order of the inter-nucleon distance, not the nuclear size. As a consequence, much of the final state interaction of the nucleon asymptotically observed corresponds to the one of the ordinary nucleon the 'small' Fock state has evolved back to. The reduction of the overall final state interaction due to the part of the trajectory where the nucleon still was in the 'small' state is small, and correspondingly difficult to disentangle. Increasing the lifetime of the 'small' Fock state by increased momentum (time dilatation) is possible, but involves enormous momentum transfers, i.e. unpractically small cross sections.

The contributions of J.M. Laget and D. Voutier presented in this parallel session[8] therefore approach this problem from a different angle. They chose to study (e,e'p) reactions on the *deuteron*. The emphasis is not on the "transparency", but the reduction of the final state interaction between the 'small' Fock state and the other nucleon[9].

In the (e,e'p) process studied, the authors select the kinematics such as to start from the components of low momentum of the initial deuteron; the wave function for this configuration is well known. The selection is performed by ensuring that the scattered electron has an energy that corresponds to the Bjorken scaling variable  $x=1$ . At the same time, the recoiling proton is selected to correspond to a momentum of the (unobserved) neutron of  $\sim 600\text{MeV}/c$ . This implies that a final state interaction between the recoiling Fock state and the neutron with momentum transfer of the order of  $600\text{MeV}/c$  had taken place. The signal for colour transparency is a reduction of the final state interaction as compared to the one calculated from the standard N-N interaction.

Laget and Voutier have studied the kinematical range accessible at a high-energy, high luminosity facility, and have identified the kinematics where the standard final state interaction between proton and neutron has a large effect on the  $D(e,e'p)$  cross section. For this kinematics they then have introduced the change of the interaction cross section due to colour transparency, and the effects of the finite coherence length, using standard parametrizations.

They find, that there are indeed kinematics at large momentum transfers,  $Q^2=6-16\text{GeV}/c^2$ , where the normal nucleonic FSI has a large effect on the cross section (factors of 2 to 3), and where the colour transparency effect leads to a large reduction. Given the good control over the deuteron wave function and the normal, nucleonic final state interaction, this change can be expected to be interpretable in an unambiguous way.

The simulation of potential experiments shows, that for electron energies in the several -  $10\text{GeV}$  range, for an external high-intensity electron beam (Lu-

minosity  $10^{38} \text{ cm}^{-2}\text{s}^{-1}$ ) and spectrometers that can stand this luminosity, this type of experiment is feasible. Count rates of the order of several 10 per hours make this an entirely realistic approach.

The simulations also show that for large-acceptance spectrometers, with their corresponding much lower luminosity limits, the experiment still is practical as far as the count rates go. However, the energy resolution does present problems: to properly measure the missing momentum (i.e. the momentum transfer in the final state interaction) and to guarantee elastic scattering (i.e. absence of particle production) the resolution of proposed large acceptance spectrometers such as MEMUS is not good enough; for this option, further work is required.

## 5 Conclusion

The theory of color transparency is likely to evolve much before ELFE beams are available for physics. Experience will be gained from CEBAF and HERMES runs; understanding in detail hadron propagation in matter is a challenging goal much related to the physics of confinement.

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